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AUTHOR Dunlop, David L.; Fazio, Frank
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ABSTRACT

The purpose of this study was to investigate the relationship between a student's stated preference for solving a problem and his/her actual problem solving methodology. Approximately 116 science students between the ages of 15 and 22 were given an 18 item abstract preference survey. Each student was interviewed and given the opportunity to solve three different tasks: (1) fossil identification; (2) a balance problem; and (3) an electrical circuit problem. Results included the following: (1) considering all tasks, there was a similarity in performances of males and females; (2) on tasks involving the fossil and electrical circuit, the shift of preference was from a concrete mode to an abstract mode; (3) on the balance task, the shift of preference was from abstract to concrete; (4) college students were less likely to shift preferences; and (5) students' preferences for solving a hypothetical model may quickly change when the problem is real. (RH)

A COMPARISON OF STUDENT PREFERENCES AND ACTUAL PERFORMANCE IN PROBLEM SOLVING TASKS WITHIN A PIAGETIAN SETTING

by

David L. Dunlop
University of Pittsburgh at Johnstown
Johnstown, Pa. 15904

and

Frank Fazio
Indiana University of Pennsylvania
Indiana, Pa. 15701

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INTRODUCTION

A cursory examination of the literature which has been published during the past few years in educational journals will readily indicate that a vast number of studies have used a Piagetian-type model when studying human learning and/or academic performance. A current line of research in this general area is related to the student's level of performance. Sayre and Ball state that formal operational students tend to have better science grades than non-formal students taking the same course (8). They also report no significant difference in the performance of males and females on identical tasks. This, they state, is in contradiction to studies by Bridgham (1) and Elkind (5).

One variable which may influence a student's performance is his/her acquisition of logical structures (cognitive level of development). Sayre and Ball (8) seem to support this point of view when they state that the lower grades received by non-formal operational students may be due, in part, to their cognitive developmental stages, over which they have little control. Raven also recognizes the importance of the acquisition of logical structures in helping to determine the level at which a student will perform; however, he indicates that the acquisition of these structures can be facilitated through instruction (7).

Another variable which influences the level of operations at which a student functions is that of individual preference. The role of an individual's preference in helping to determine the level at which that

individual prefers to function has been examined by Dunlop and Fazio (3, 4). They also present data which demonstrate the lack of a significant correlation between an individual's cognitive level of operations and his/her written preference in selecting a method by which to solve a problem.

OBJECTIVES

The purpose of this study was to investigate the relationship between a student's stated preference for solving a problem and his/her actual problem solving methodology. The general form of the null hypothesis under consideration was as follows: There is no significant difference between the manner in which students state that they will attempt to solve a problem and the manner in which they actually do attempt to solve the problem. In addition this paper will examine the degree to which formal and non-formal students are successful in using their preferred method of problem solving.

DESIGN

Approximately 116 science students between the ages of 15 and 22 were given an 18 item abstract preference survey. This survey, still in an early stage of development, consists of 18 written problem solving tasks and requires the subjects to state their preferences concerning methods for arriving at a solution to each task. The methods of solution for each task were ranked by a panel of

educators according to the degree of abstraction represented, thus allowing an abstract preference score to be calculated. The test-retest reliability for 28 people was 0.84. The validity of the preference instrument was based upon the theoretical construct for concrete and formal as described by the Piagetian developmental theory (6).

Students with a high level of abstract reasoning ability were identified by scores from the Shipley Test of Abstract Reasoning (9). This particular test was used because earlier studies have provided some evidence that groups of students with high abstract reasoning abilities are similar to groups of students found to be in the formal stage of operations as defined by traditional Piagetian types of tests (2).

Several days after the completion of the paper and pencil tests mentioned above, each student was individually interviewed and given the opportunity to solve three different tasks. These tasks were taken from the preference survey and included a fossil identification task, a balance problem, and an electrical circuit problem.

Records were kept which allowed comparisons to be made concerning the actual manner in which a student attempted to solve a problem and the manner which the student previously indicated as a preferred method of solution. The McNemar test for the significance of changes as described in Siegel (10) was used to examine the null hypothesis for the following three different sub-groups: sex, age, and cognitive

level of operations. In addition the degree to which the formal and non-formal operational students were successful in solving the problems was examined.

RESULTS

From an examination of Tables 1-6, several points may be made concerning the degree to which students change their preferences after actually being asked to solve a problem. (It should be noted that for Tables 1-7 task number one is the fossil identification problem, task number two is the electric circuit problem, and task number three is the balance problem.) First, when considering all three tasks, there is a similarity of performance between males and females. That is, both groups of students generally have a significant change in their preference after being asked to solve the tasks. In tasks one and two this shift of preference is from the concrete mode to the abstract mode, while in task three the shift is in the opposite direction.

Second, the similarity that existed between the males and females is not evident when examining high school students in comparison with college students. In this situation we can see that the college students are less likely to shift their preferences than are the high school students. The high school students show significant changes in their preferences in tasks one and three. However, the direction of their shift is toward the abstract preference in task one but toward the concrete preference in task three.

TABLE 1 -- Female Student's Preferred Method of Problem Solving Before and After Being Asked to Solve the Actual Problem Solving Tasks.

TASK 1

Written Preference	Actual Selection: Concrete Method	Actual Selection: Abstract Method
Abstract Method	7	11
Concrete Method	42	23

$\chi^2 = 7.5^a$

TASK 2

Written Preference	Actual Selection: Concrete Method	Actual Selection: Abstract Method
Abstract Method	12	28
Concrete Method	21	22

$\chi^2 = 6.62^a$

TASK 3

Written Preference	Actual Selection: Concrete Method	Actual Selection: Abstract Method
Abstract Method	17	10
Concrete Method	50	6

$\chi^2 = 4.35^a$

[a]For 1 d.f. chi-square (.01) = 6.64, chi-square (.05) = 3.84

TABLE 2 -- Male Student's Preferred Method of Problem Solving Before and After Being Asked to Solve the Actual Problem Solving Tasks.

TASK 1

Written Preference	Actual Selection: Concrete Method	Actual Selection: Abstract Method
Abstract Method	2	2
Concrete Method	15	14

$\chi^2 = 7.56^a$

TASK 2

Written Preference	Actual Selection: Concrete Method	Actual Selection: Abstract Method
Abstract Method	7	3
Concrete Method	15	8

$\chi^2 = 0^a$

TASK 3

Written Preference	Actual Selection: Concrete Method	Actual Selection: Abstract Method
Abstract Method	15	4
Concrete Method	11	3

$\chi^2 = 6.72^a$

[a]For 1 d.f. chi-square (.01) = 6.64, chi-square (.05) = 3.84.

TABLE 3 -- High School Student's Preferred Method of Problem Solving Before and After Being Asked to Solve the Actual Problem Solving Tasks.

TASK 1

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	6	10
	Concrete Method	24	32

$\chi^2 = 16.45^a$

TASK 2

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	12	20
	Concrete Method	24	16

$\chi^2 = 0.32^a$

TASK 3

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	20	4
	Concrete Method	43	5

$\chi^2 = 7.84^a$

[a]For 1 d.f. chi-square (.01) = 6.64, chi-square (.05) = 3.84.

TABLE 4 -- College Students' Preferred Method of Problem Solving Before and After Being Asked to Solve the Actual Problem-Solving Tasks.

TASK 1

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference: Abstract Method		4	3
Written Preference: Concrete Method		30	8

$\chi^2 = 0.75^a$

TASK 2

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference: Abstract Method		7	12
Written Preference: Concrete Method		12	14

$\chi^2 = 1.71^a$

TASK 3

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference: Abstract Method		12	10
Written Preference: Concrete Method		18	5

$\chi^2 = 2.12^a$

[a]For 1 d.f. chi-square (.01) = 6.64, chi-square (.05) = 3.84.

TABLE 5 -- High Abstract Ability (Formal) Student's Preferred Method of Problem Solving Before and After Being Asked to Solve the Actual Problem Solving Tasks.

TASK 1

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	5	7
	Concrete Method	29	16

$\chi^2 = 4.76^a$

TASK 2

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	10	18
	Concrete Method	14	15

$\chi^2 = 0.64^a$

TASK 3

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	15	9
	Concrete Method	30	3

$\chi^2 = 6.72^a$

[a]For 1 d.f. chi-square (.01) = 6.64, chi-square (.05) = 3.84

TABLE 6 -- Low Abstract Ability (Non-Formal) Student's Preferred Method of Problem Solving Before and After Being Asked to Solve the Actual Problem Solving Tasks.

TASK 1

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	1	3
	Concrete Method	12	9

$\chi^2 = 4.90^a$

TASK 2

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	3	6
	Concrete Method	8	8

$\chi^2 = 1.45^a$

TASK 3

		Actual Selection: Concrete Method	Actual Selection: Abstract Method
Written Preference	Abstract Method	4	1
	Concrete Method	16	4

$\chi^2 = 0.13^a$

[a]For 1 d.f. chi-square (.01) = 6.64, chi-square (.05) = 3.84

TABLE 7 -- Percentages of students attempting and successfully solving three tasks in the manner that they previously stated to be their preference.

Group	% Attempting Abstract Solution	% Successful	% Attempting Concrete Solution	% Successful
		TASK ONE		
Concrete	50.0	00.0	36.8	21.1
Formal	62.5	37.5	52.4	26.2
		TASK TWO		
Concrete	28.6	00.0	50.0	6.3
Formal	76.2	23.8	65.5	37.9
		TASK THREE		
Concrete	0.0	0.0	85.0	65.0
Formal	5.9	0.0	96.9	87.5

When comparing the high abstract group (formal operational) with the low abstract group (concrete operational), we find that in tasks one and two the formal operational students are similar to the concrete operational students in the degree to which they changed their preferences. For both groups the shift in task one was toward the abstract mode and the shift in task two was not significant. In task three the high ability group made a significant shift toward the concrete mode but the low ability group made no significant change in their preferences.

Finally, if one examines Tables 1-6 it may be calculated that students made significant changes in their preference approximately 83% of the time in task one, 16% of the time in task two, and 66% of the time in task three.

From Table 7 one can see the percentages of concrete and formal operational students which attempted and successfully completed the task as they indicated on the preference survey. Although several concrete students preferred to solve the problems in an abstract manner, they were unsuccessful in their efforts. However, when examining the success for those who preferred to use the concrete approach, one may see that the concrete students were almost as successful as the formal students.

Results from a previous study (4) which may be of interest at this time due to their close relationship to this paper have been included in Appendix A. These results indicate that abstract preference scores of students do not significantly differ from grade to grade; however, abstract

ability, as one would expect, does significantly increase as grade level increases.

DISCUSSION AND SIGNIFICANCE

The results of this study, when considered together with the results of earlier studies, indicate several points which should be discussed and summarized.

First, the degree of abstractness present in an individual's preference for a particular method to solve a problem does not appear to be directly related to that individual's abstract ability. Thus it is not uncommon to find students with high ability in abstract reasoning (formal operational students) preferring a more concrete approach when solving a particular task. In many cases this is probably the result of the student's ability to recognize that the most efficient solution to the problem is by the use of a concrete approach. Since preference does not seem to be directly dependent upon ability, it is not uncommon to discover that students with low abstract ability (concrete operational students) frequently prefer to attempt a problem solving task with an abstract approach.

The incongruity between a student's potential and preferred level of operation in a given situation is no problem for the formal operational students; however, it can become a problem for the concrete operational students who, because of their preference, decide to attempt to solve a problem using an abstract approach which is beyond their ability to

successfully implement. In some cases the students will recognize that they are unable to implement their preferred method of solving the problem and will modify their approach. However, since this is not always the case, it seems that there may be some merit to the idea of including instruction in a science curriculum which will help students to recognize personal limitations and suitable approaches to a problem solving task.

This study has demonstrated that students' preferences which indicate a preferred method for solving a hypothetical problem may quickly change when the problem becomes real. This evidence shows the need for teachers to be aware of the difficulty which some students will have in stating a priori how they would attempt to solve a problem. Teachers must be flexible and willing to allow students to change their pre-stated approach to a given problem solving situation or inquiry exercise.

When considering the manner in which students change their preference, one can see that the direction of change (from an abstract approach to a concrete approach or vice versa) is more consistent within a given task for several groups of students than it is among several tasks for one group of students. One possible interpretation is that, for many students, actual preferences are task dependent. If this is true teachers could, when appropriate, encourage abstract thought and abstract performance by judicial selection of classroom activities. By the same process, of course, teachers may be able to

prevent concrete operational students from creating an incongruity between their ability and their preferences. This should then increase the rate of success for concrete operational students when they are working on a problem solving task.

Additional work in this area with attention to the matching of classroom activities, student ability, and individual preferences may be useful for the classroom science teacher.

APPENDIX A

Tables From Previous Studies

A Simple Analysis of Variance of Abstract Ability Scores for Five Different Grade Levels

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Groups	4	313.67	78.5	14.51 *
Within Groups	288	1557.51	5.41	
Total	292	1871.18		

*p .01

A Simple Analysis of Variance of Abstract Preference Scores for Five Different Grade Levels.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Groups	4	15.22	3.80	1.15
Within Groups	288	1004.78	3.49	
Total	292	1020.00		

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